Appendix B - Population Modeling

Population Model Overview

WinEquus is a program to simulate the population dynamics and management of wild horses created by Stephen H. Jenkins of the Department of Biology, University of Nevada at Reno. For further information about this model, you may contact Stephen H. Jenkins at the Department of Biology/314, University of Nevada, Reno, NV 89557.

Detailed information is provided within the WinEquus program available at http://unr.edu/homepage/jenkins, and will provide background about the use of the model, the management options that may be used, and the types of output that may be generated.

The population model for wild horses was designed to help wild horse and burro specialists evaluate various management strategies that might be considered for a particular area. The model uses data on average survival probabilities and foaling rates of horses to project population growth for up to 20 years. The model accounts for year-to-year variation in these demographic parameters by using a randomization process to select survival probabilities and foaling rates for each age class from a distribution of values based on these averages. This aspect of population dynamics is called environmental stochasticity, and reflects the fact that future environmental conditions that may affect wild horse population's demographics can't be established in advance. Therefore each trial with the model will give a different pattern of population growth. Some trials may include mostly "good" years, when the population grows rapidly; other trials may include a series of several "bad" years in succession. The stochastic approach to population modeling uses repeated trials to project a range of possible population trajectories over a period of years, which is more realistic than predicting a single specific trajectory.

The model incorporates both selective removal and fertility treatment as management strategies. A simulation may include no management, selective removal, fertility treatment, or both removal and fertility treatment. Wild horse and burro specialists can specify many different options for these management strategies such as the schedule of gathers for removal or fertility treatment, the threshold population size which triggers a gather, the target population size following a removal, the ages and sexes of horses to be removed, and the effectiveness of fertility treatment.

To run the program, one must supply an initial age distribution (or have the program calculate one), annual survival probabilities for each age-sex class of horses, foaling rates for each age class of females, and the sex ratio at birth. Sample data are available for all of these parameters. Basic management options must also be specified.

Population Modeling - McCullough Peaks HMA

To complete the population modeling for the McCullough Peaks HMA, version 1.40 of the WinEquus program, created April 2, 2002, was utilized.

Objectives of Population Modeling

Review of the data output for each of the simulations provided many useful comparisons of the possible outcomes for each alternative. Some of the questions that need to be answered through the modeling include:

- Do any of the Alternatives "crash" the population?
- What effect does fertility control have on population growth rate?
- What effects do the different alternatives have on the average population size?

Population Data, Criteria, and Parameters utilized for Population Modeling

Initial age structure for the 2003 herd was developed from age structure data collected during the 1999 McCullough Peaks HMA wild horse gather. The 1999 release data was combined with a data set developed for the estimated 14 animals not gathered in 1999. This data set was based on age structure data from the 1999-released population.

The following table displays the age structure for released animals, the estimated age structure for animals not gathered without age data, and the estimated post gather population for 1999.

Initial Age Structure 1999

Age Class	McCullough Peaks Released Animals – 1999		Typical Population for 10 Un-gathered animals and 4 studs missing age data*		McCullough Peaks Estimated Post Gather Population 1999	
	Females	Males	Females	Males	Females	Males
Foals	6	2	1	0	7	2
1	2	0	0	0	2	0
2	2	3	0	0	2	3
3	2	0	0	0	2	0
4	3	2	0	0	3	2
5	1	0	0	0	1	0
6	9	1	1	0	10	1
7	7	3	1	0	8	3
8	6	3	1	0	7	3
9	7	2	1	0	8	2
10-14	7	15	1	2	8	17
15-19	4	10	0	1	4	11
20+	3	7	0	5	3	12
Total	59	48	6	8	65	56

***** Data was estimated based on percentages of the 1999 released animals.
Post Gather (1999) Total = 121 Sex Ratio = 46% Males and 56% Females

The following table shows the proposed age structure will try to be achieved:

Proposed Initial Age Structure
Post Gather – 2004

Age Class	Percent of Population
<5	25%
5 – 9	55%
10+	20%

All simulations used the survival probabilities, foaling rates, and sex ratio at birth that was supplied with the WinEquus population model for the Garfield Range HMA (granites_berger.sin & granites_berger.fin). Survival and foaling rate data were extracted from, "Wild Horses of the Great Basin", by J. Berger (1986, University of Chicago Press, Chicago, IL, xxi + 326 pp.). They are based on Joel Berger's 6 year study in the Granite Range HMA in northwestern Nevada.

Survival probabilities and foaling rates utilized in the population model for five alternatives analyzed, including the Proposed Action and No Action Alternatives, and are displayed in the following table:

Survival Probabilities and Foaling Rates

Age Class	Survival Probabilities		Foaling Rates
	Females	Males	
Foals	.917	.917	0
1	.969	.969	0
2	.951	.951	.35
3	.951	.951	.40
4	.951	.951	.65
5	.951	.951	.75
6	.951	.951	.85
7	.951	.951	.90
8	.951	.951	.90
9	.951	.951	.90
10-14	.951	.951	.85
15-19	.951	.951	.70
20+	.951	.951	.70

The following is the sex ratio at birth was utilized in the population modeling for Alternatives I - V:

Sex ratio at Birth:

50% Males
50% Females

To date, one herd area has been studied using the 2-year PZP vaccine. The Clan Alpine study, in Nevada, was started in January 2000 with the treatment of 96 mares. The test resulted in fertility rates in treated mares of 6% year one, 18% year two, 32% year three and 43% year four. This

data must be compared to normal fertility rates in untreated mares of 50/60% in most populations. The Clan Alpine fertility rate in untreated mares collected in September of each year by direct observation averaged 51% over the course of the study.
The following percent effectiveness of fertility control was utilized in the population modeling for Alternatives I and III:

Year 1: 94%

Year 2: 82%

Year 3: 68%

The following table displays the removal parameters utilized in the population model for Alternatives I, II, III, and IV:

Removal Criteria
(Alternatives I, II, III, & IV)

Age	***Percentages for Removals***	
	Females	**Males**
Foal	100%	100%
1	90%	90%
2	90%	90%
3	90%	90%
4	90%	90%
5	10%	10%
6	10%	10%
7	10%	10%
8	10%	10%
9	10%	10%
10-14	90%	90%
15-19	90%	90%
20+	90%	90%

The following table displays the contraception parameters utilized in the population model for Alternative I and Alternative III:

Contraception Criteria

(Alternatives I & II)

Age Class **(Mares)**	**Percentages for Fertility Treatment**
1- 4 yrs	100%
5 – 9	75%
10+	100%

Population Modeling Criteria

The following summarizes the population modeling criteria that are common to the Alternative I (Proposed Action), and Alternatives II, III, IV, and Alternative V (No Action):

- Starting Year: 2003
- Initial gather year: 2004
- Gather interval: regular interval of three years
- Gather for fertility treatment regardless of population size: No
- Continue to gather after reduction to treat females: Yes
- Sex ratio at birth: 50% males
- Percent of the population that can be gathered: 90%
- Minimum age for long term holding facility horses: 10 years old
- Foals are NOT included in the AML
- Simulations were run for ten years with 50 trials each

The following table displays the population modeling parameters utilized in the model:

Population Modeling Parameters

Modeling Parameter	**Alternative I** Proposed Action **(Remove to Middle & Fertility Control)**	**Alternative II** **(Remove to Middle & No Fertility)**	**Alternative III** **(Remove to Low & Fertility Control)**	**Alternative IV** **(Remove to Low & No Fertility)**	**Alternative V** No Action **(No Removal & No Fertility Control)**
Management by removal and fertility control	Yes	No	Yes	No	N/A
Management by removal only	No	Yes	No	Yes	N/A
Threshold Population Size for Gathers	140	140	140	140	N/A
Target Population Size Following Gathers	100	100	70	70	N/A
Gather for fertility control regardless of population size	No	No	No	No	N/A
Gathers continue after removals to treat additional females	Yes	No	Yes	No	N/A
Effectiveness of Fertility Control: year 1	**94%**	N/A	94%	N/A	N/A
Effectiveness of Fertility Control: year 2	**82%**	N/A	82%	N/A	N/A
Effectiveness of Fertility Control: year 3	68%	N/A	68%	N/A	N/A

Population Modeling Results - McCullough Peaks HMA

Population Modeling Results

Population size in ten years

Out of 50 trials in each simulation, the model tabulated minimum, average, and maximum population sizes. The model was run from 2004 to 2013 to determine what the potential effects would be on population size for the proposed action and alternatives. These numbers are useful to make relative comparisons of the different alternatives, and potential outcomes under different management options. The data displayed within the tables is broken down into different levels. The lowest trial, highest trial, and several in between are displayed for each simulation completed. According to the creator of the modeling program, this output is probably the most important representation of the results of the program in terms of assessing the effects of proposed management, because it shows not only expected average results but also extreme results that might be possible.

Population Sizes in 11 years - Minimum

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	101	100	56	70	494
10th Percentile	101	101	71	70	502
25th Percentile	102	103	74	73	514
Median Trial	**106**	**108**	**78**	**76**	**532**
75th Percentile	114	114	81	80	565
90th Percentile	118	119	87	83	593
Highest Trial	125	123	89	91	801

This table shows that in eleven years and 50 trials for each alternative, the lowest number of 0-20+ year old horses ever obtained was 56 under Alternative III. Half of the trials were greater than the median and half were less than the median. Additional interpretation may be made by comparing the various percentile points. For example, for the Proposed Action, only 10% of the trials resulted in fewer than 101 wild horses as the minimum population, and 10% of the trials resulted in a minimum population larger than 118 wild horses. In other words, 80% of the time, one could expect a minimum population between these two values for the Proposed Action, given the assumptions about survival probabilities, foaling rates, initial age-sex distribution, and management options made for this simulation.

The Proposed Action (selective removal to mid point AML = 100 with fertility control) reflects the 2nd highest minimum population of all the alternatives. The simulation results for Alternative II (selective removal to mid AML = 100 without fertility control) are similar to Alternative I. The simulation results for Alternatives III (selective removal to lo AML = 70 with fertility control) and IV (selective removal to lo AML = 70 without fertility control) are both similar, but the lowest population totals fall below or at the low AML of 70. Alternative V (No Action) reflects the highest minimum population level of all of the trials.

None of the results obtained for any of the alternatives indicate that a crash of the population would occur if the alternative were implemented. The level to which the population is gathered (lower or mid limit of the management range/AML) appears to be more of an influence to the population size than fertility control.

The lowest population size ever obtained (56 head) is less than the lower level of the management range of 70 wild horses. However, for 90% of the time the simulation indicates that the population will be 87 head or more, which is slightly higher than the lower level of the management range. This occurs due to the assumptions made by the model, which include census accuracy, effectiveness of the gather, and mares that foal following the gather.

Population Sizes in 11 years - Average

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	143	157	126	136	1252
10th Percentile	147	161	137	150	1382
25th Percentile	150	165	140	152	1493
Median Trial	**157**	**171**	**143**	**159**	**1667**
75th Percentile	161	177	148	163	1911
90th Percentile	164	180	154	170	2176
Highest Trial	170	184	157	173	2356

This table displays the average population sizes obtained for the 50 trials run for each alternative. The average population size across eleven years ranged from a low of 143 wild horses under the Alternative III, to a high of 2356 wild horses under Alternative V (No Action).

Population Sizes in 11 years - Maximum

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	183	195	178	217	2411
10th Percentile	188	206	192	219	2746
25th Percentile	195	217	199	226	3228
Median Trial	**206**	**234**	**206**	**242**	**3632**
75th Percentile	214	250	214	266	4275
90th Percentile	226	264	218	284	5112
Highest Trial	240	272	226	305	5941

This table displays the largest populations that could be expected out of 50 trials for each alternative. The figures for the Lowest Trial represent what the population is likely to be in 2015. All figures are very similar under Alternatives I – IV because of the same starting population, and gather efficiency, etc., is assumed. The numbers vary due to randomness and assumptions inherent to the modeling program.

Average Growth Rates in ten years

Average growth rates were obtained by running the model for 50 trials from 2004 to 2014 for the proposed action and each alternative. The following table displays the results obtained from the model:

Average Growth Rate in 10 Years

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	10.2%	14.6%	13.1%	18.3%	14.7%
10th Percentile	12.5%	18.0%	13.9%	19.2%	18.1%
25th Percentile	13.3%	19.5%	15.3%	19.7%	19.4%
Median Trial	**15.8%**	**21.3%**	**16.7%**	**21.7%**	**21.4%**
75th Percentile	17.0%	23.2%	17.7%	23.3%	22.6%
90th Percentile	19.1%	25.0%	18.8%	24.9%	24.5%
Highest Trial	20.1%	25.1%	19.3%	28.3%	26.9%

As expected, the two alternatives implementing fertility control (Proposed Action and Alternative III) reflect the lowest overall median growth rate. For the median trial, the fertility control alternatives are 5.5% and 5.0% lower than the respective non-fertility control alternative. For the 10^{th} Percentile trial, the fertility control alternatives are 5.5% and 5.3% lower than the respective non-fertility control alternative. The lowest trial growth rate of 10.2% for the Proposed Action does not appear to be a direct result of the management options, but appears to reflect the random nature of the model and the ability to show extremes in possible outcomes. The one particular trial for this alternative that resulted in the low growth rate must be reflecting a "bad" year. The range of growth rates is a reasonable representation of what could be expected to occur in a wild horse population.

Totals in eleven years – Gathered, Removed and Treated

Totals in 11 Years -- Gathered

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	283	245	171	184	NA
10th Percentile	316	266	299	205	
25th Percentile	321	302	321	223	
Median Trial	**432**	**338**	**330**	**248**	
75th Percentile	486	372	354	308	
90th Percentile	504	399	365	381	
Highest Trial	528	414	510	419	

Totals in 11 Years -- Removed

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	75	165	65	127	NA
10th Percentile	105	174	94	149	
25th Percentile	115	202	112	158	
Median Trial	**140**	**228**	**123**	**174**	
75th Percentile	180	255	138	226	
90th Percentile	192	274	150	269	
Highest Trial	216	275	186	291	

Totals in 11 Years – Treated

Alternative	Proposed Action	II	III	IV	V
Lowest Trial	54	NA	37	NA	NA
10th Percentile	61		60		
25th Percentile	68		62		
Median Trial	**86**		**66**		
75th Percentile	97		76		
90th Percentile	106		84		
Highest Trial	110		108		

The number of horses gathered does not differ greatly between alternatives because gather criteria is the same for all alternatives. What does differ widely is the number of wild horses removed and treated under the different alternatives. The Proposed Action and Alternative II are similar in the number of animals removed, because each of these alternatives includes gathering to the target number of 100, which is mid AML. Similarly, Alternatives III and IV are also similar because they both include a target number of 70.

Population Modeling Summary – McCullough Peaks HMA

Population Modeling Summary

To summarize the results obtained by simulating the range of alternatives for the McCullough Peaks HMA wild horse gather, the original questions can be addressed.

- Do any of the Alternatives "crash" the population?

None of the alternatives indicate that a crash is likely to occur to the population. Minimum population levels and growth rates are all within reasonable levels, and adverse impacts to the population are not likely.

- What effect does fertility control have on population growth rate?

As expected, the two alternatives implementing fertility control (Proposed Action and Alternative III) reflect the lowest overall median growth rate. For the median trial, the fertility control alternatives are 5.5% and 5.0% lower than the respective non-fertility control alternative. The target size to which the population is gathered to (100 or 70 wild horses) appears to have minimal impacts to growth rates, as demonstrated by the growth rates being quite similar for the Alternatives II and IV (no fertility control alternatives).

- What effect do the different alternatives have on the average population size?

The level to which the population is gathered (lower or middle limit of the management range) appears to be more of an influence to population size than fertility control, as there are larger differences within the population minimums from the lower limit of the management range to the middle limit of the management range alternatives. It is clear that fertility control with a gather to the lower limit of the management range would produce the lowest minimum population, and no fertility control with a gather to the middle limit of the management range would produce the highest minimum population, for the four action alternatives. As expected, the No Action Alternative results in the highest minimum population.

- What effects do the different alternatives have on the genetic health of the herd?

The minimum population levels and growth rates are all within reasonable levels for the Proposed Action and Alternatives II, and V, therefore, adverse impacts to the population are not likely under these alternatives. Under Alternatives III and VI, the minimum population level falls below Dr. E. Gus Cothran's recommendation of "maintaining an average herd size of 100 adult horses" and may result in a loss of genetic variation. The drop in population numbers may have detrimental/adverse impact to the genetic viability of the herd, especially, if Alternative III (Selective Removal to lo AML = 70 and fertility control) was selected.